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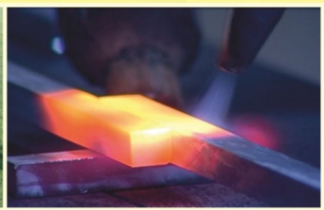


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# Assessment Of Groundwater Quality For Human Consumption And Agricultural Use In Ilara-Mokin, Ondo State, Nigeria.

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**Key words:**
Groundwater quality, ionic toxicity, agricultural activity, irrigation water, quality, Ilara-mokin community.

**A B S T R A C T**

*Groundwater is an important source of freshwater for drinking, domestic, and agricultural uses in many regions of the world. Contamination of groundwater by human and industrial activities is a serious concern nowadays. Thus, analysis of the water quality is of great importance in preserving and protecting the ecosystem. A research was conducted to assess the degree of ion toxicity of groundwater sources which include; borehole and shallow well for drinking, domestic and agricultural purposes. Sixteen groundwater samples were analyzed for physico-chemical parameters, and results indicates pH (93.8 %), temperature (68.8 %), dissolved oxygen (100.0 %), biochemical oxygen demand (13.0 %), calcium (93.8 %), Iron (100 %), manganese (31.3 %), lead (13 %) and cadmium (43.8 %) of the water samples fell beyond the WHO water standard permissible limits. 100% of other parameters such as Electrical conductivity, Chloride, Turbidity, Total hardness, Acidity, Sulphate, Nitrate, Total dissolve solid, Total soluble solid, Sodium, Potassium, Magnesium, Copper and Zinc fell within the permissible limits. The water quality was classified as excellent, good, suitable and unsuitable based on sodium adsorption ratio, percentage sodium, magnesium hazard, soluble sodium percent and Kelley's ratio using standard equations. For irrigation use 100 % of the water samples for SAR, KI, Na % and SSP were suitable while 62.5 % were unsuitable according to MH classification. From this study, it is suggested that the evaluation of water quality parameters as well as water quality management should be carried out periodically to protect water resources.*

## 1. Introduction

Water is one of the most valuable natural resource essential to human and other living things existence (Deshpande and Aher, 2012). It covers about two third of the earth surface. In the twenty first century quality freshwater is one of the most crucial environmental issues (Mohamed and Zahir, 2013). Quality of supplied water is of great importance to the welfare of humanity. Water borne diseases are as a consequence of polluted water consumption either directly or indirectly. Its usefulness for different human activities is dependent on its quality (Yehia, 2013). Water quality is affected by natural and anthropogenic effects such as local climate, geology and irrigation practices (Tomar et al., 2012). Quality of groundwater is of great importance and has attracted the attention of researchers in different parts of the country. Inadequate, unreliable and irregular public or municipal water supply is a major problem in rural areas. Thus, there is a high dependency on untreated ground water abstracted from dug well s and borehole systems (Ocher, 2006). When wastes are disposed and subsequently find its way into the subsurface environment, it may remain concealed for years and become gradually dispersed over a wide range of area of ground water aquifer thereby polluting the ground water and making it unsuitable for human consumption and other uses. Suitability of water for various uses is dependent on the type and concentration of dissolved minerals (Christopher and Yusoff, 2011). Knowing the potential influence of human activities on ground water quality, this study was undertaken to determine the physico-chemical and elemental composition of the groundwater sample, identify some common pollutants and establish a correlation matrix among the ground water quality parameters with each other by randomly collected ground water samples from dug wells and bore wells covering the entire Ilara Mokin town.

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## 2. Material and Methods

### *2.1 Study Area*

Ilara-Mokin community is in Ifedore LGA of Ondo State, South-Western Nigeria as shown on Figure 1. The town is located between latitude 07°21'16" and 07°22'20" N and longitude 05°05'58" and 05°07'12" E. The area has a climate characterized by two seasons; the wet season and the dry season. The wet season starts from around mid-March and ends in October with an average rainfall of 1500 mm to 2000 mm while the dry season starts around November and ends in March with an average maximum temperature of about 33 ˚C. The mean monthly relative humidity is less than 70 % (Odubanjo et al., 2011).

### *2.2 Sample Collection*

Groundwater samples were collected from bore wells and municipal boreholes at 16 sampling stations within Ilara Mokin community during July 2015. Samples taken from each station were stored in pre-cleaned plastic polyethylene bottles. The polyethylene bottle was rinsed with the water sample before been filled and store in an ice cooler. The samples were taken to the Laboratory for physio-chemical analysis.

### *2.3 Sample Analysis*

Chemical analysis was carried out using Standard Methods for the Examination of Water and Wastewater (APHA, 1989). Water quality parameters pH using pH meter (SearchTech PHS-3C), temperature using thermometer, turbidity and electrical conductivity [EC] using the Conductivity meter (SearchTech DDS-307) and Microprocessor Turbidity (Hanna Instruments HI 93703). Other parameters were later analyzed in the laboratory. Total alkalinity and acidity were determined titrimetrically. Total hardness (TH) as CaCO3 and calcium (Ca) were analyzed titrimetrically, using standard EDTA. Magnesium hardness was calculated by taking the differential value between total hardness (TH) and calcium hardness concentrations. Dissolved oxygen (DO) was determined using Winkler's method. Biochemical Oxygen Demand (BOD5) was determined Azide modification method (APHA, 1995). Nitrate (NO3-) and sulphate (SO42-) were determined using colorimetric method. Total dissolved solid (TDS) and Total suspended solid (TSS) were determined using the AOAC method of analysis. Chloride (CI) was determined titrimetrically by standard AgNO3 titration.

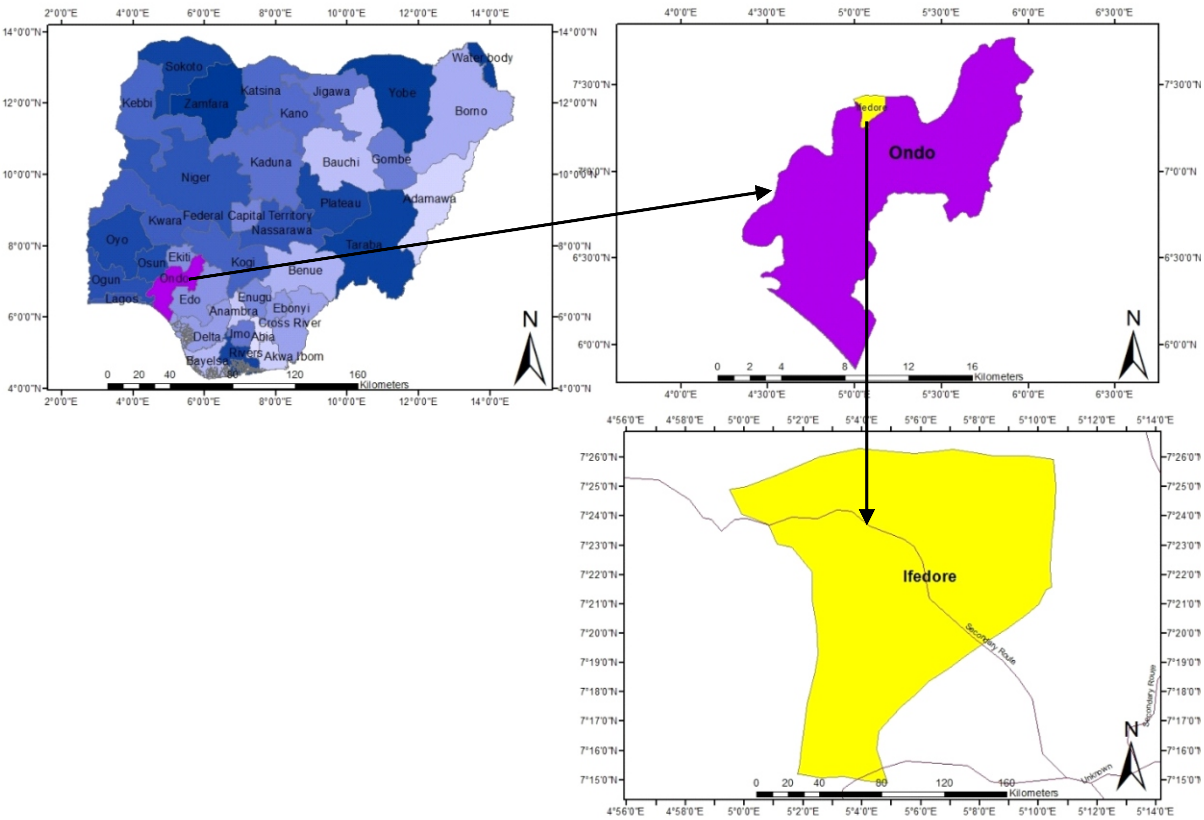


**Figure1:** Map of the study area

The content of Sodium (Na), Zinc (Zn), Calcium (Ca), Manganese (Mn), Iron (Fe), Copper (Ca), Magnesium (Mg), Cadmium (Cd), Lead (Pb) and Potassium (K) in groundwater was estimated using the atomic absorption spectrometer (varian model spectral AA 220). All parameters were expressed in milligrams per litre (mg/I) except pH (no unit), temperature (o C), turbidity (NTU) and electrical conductivity (EC) micromohs/cm (µS/cm).

Sodium Adsorption Ratio (SAR), percentage sodium (% Na), magnesium hazard (MH), kelley's ratio (KI) and soluble sodium percentage (SSP) were calculated on the basis of standard equations outlined by (Tahlawi et al., 2014; Deshpande and Aher, 2012). These equations are as follows:

$$SAR = \frac{Na^{+}}{\sqrt{\left(\frac{Ca^{2-}+Mg^{2+}}{2}\right)}} \quad \text{(i)}$$

$$Na\,\% = \frac{(Na^{+}+K^{+})}{Ca^{2+}+Mg^{2+}+Na^{+}+k^{+}} * 100 \quad \text{(ii)}$$

$$MH = \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} * 100 \quad \text{(iii)}$$

$$KI = \frac{Na^{2+}}{Ca^{2+}+Mg^{2+}} \quad \text{(iv)}$$

$$SSP = \frac{Na^{+} * 100}{Ca^{2+}+Mg^{2+}+Na^{+}} \quad \text{(v)}$$

## 3. Results and Discussion

The results are tabulated in Tables 1, 2, 3, 4 and 5 respectively. The experimental results are compared with the limit recommended by WHO and Australian and New Zealand Environment and Conservation Council, ANZECC while for irrigation purposes the results were grouped to different class according to SAR, Na %, KI, MH and SSP respectively.

### *3.1 Physical Parameters*

The quality of Ilara-Mokin well and borehole water were analyzed. Descriptive statistics on the 16 samples reveal that the mean value for Temperature, DO, Iron, Lead and Cadmium is above the permissible limit of WHO and ANZECC. Other parameters such as pH, electrical conductivity, chloride, turbidity, hardness, acidity alkalinity, BOD, sulphate, nitrate, TDS, TSS, magnesium, calcium, potassium, manganese, sodium, zinc and copper are within the permissible limits The appearance of samples is generally clear with the turbidity values ranging between 0.0 and 3.7 with a mean value of 1.02 which falls within WHO acceptable limits (5 NTU). Turbidity in water is caused by a wide variety of suspended matter, which range in size from colloidal to coarse dispersions and also range from pure organic substances to those that are highly organic in nature. The same values (ranging between 0 mg/L and 5 mg/L) were observed by (Gyamfi, 2012) while Okogbue and Ukpai (2012), got a value beyond the permissible limit which may be due to flow alteration in the unsaturated zone.

The temperature values of all groundwater samples ranges between 28 oC and 31 oC, samples 6,9,11,12, and 14 respectively are within WHO permissible limit (28 oC) while samples 1,2,3,4,5,7,8,10,13,15 and 16 respectively are above the permissible limit this is an indication of high dissolution of carbon(iv)oxide in the water samples . At such temperature range, gases such as CO2 are held in solution and increase the solubility of minerals (Okogbue and Ukpai, 2012). Investigated results of these physical parameters are given in Table 1.

Total dissolve solid is defined as the concentration of all dissolve minerals in the water (Tahlawi et al., 2014).The total dissolve solid measured in the samples ranged between 65.28 mg/L and 328.23 mg/L. The total dissolve solids measured fell below WHO permissible limit (1000mg/L) which shows a low level of dissolve minerals in the water samples. These results are lower than the values ranged between 770 mg/L to 1150 mg/L. Total suspended solid ranged between 23.48 -192.18. This indicated that all of the samples value fell below WHO permissible limit (1000 mg/L). High levels of dissolved substances are undesirable in water. Dissolved mineral, gases and organic constituent may result to displeasing colour, odor and taste. High level of dissolved organic chemicals may deplete the dissolved oxygen in the water (Gyamfi et al., 2011). Gyamfi et al. (2011) reported a value range between 1 mg/L and 4 mg/L which indicate a low level of dissolved substances.

The pH of the samples fell within the range of 5.50-7.0 as shown in Table 1. Almost all the samples (1,2,3,4,5,6,7,8,9,10,11,12,13,14 and15) fell below WHO permissible limit (6.5-8.5) except sample 16 which fell within. Most of the groundwater samples had pH values below the acidic limit of 6.5. pH value less than 6.5 are considered too acidic for human consumption and can cause health problems such as acidosis (Ackah et al., 2011).

The acidic nature of most of the samples might be due to high mineral rich in rocks making up the aquifers. These results are Comparable with 6.79 to 7.22 that were reported by Akoteyon and Soladoye (2011), which indicates the presence of very weak basic salt present in the water sample of that area. Electrical conductivity in water sample is an indication of dissolve ion. The Electrical conductivity values of all groundwater samples are found to be in the range of 90 µS/cm and 541 µS/cm as shown in Table 1. The values indicate that all the samples fell within WHO permissible limit (1500 µS/cm). With the value obtained all the water samples are save for consumption for both human beings and livestock. The low levels of electrical conductivity indicate a low level of dissolve ion. These values are lower compare with 214 µS/cm to 2830 µS/cm reported by (Ackah et al., 2011), which is an indication of high levels of dissolve ions in the water samples The chloride concentration of all the samples ranged between 29.78 mg/L and 136.13 mg/L. Chloride concentration of all the samples are found to be below the WHO permissible limit (250 mg/L). Chloride ions is one of the major inorganic anion in water which its high content may harm metallic pipes and structures. In water, salty taste is produced by high chloride concentration. High concentration of chloride is injurious to people suffering due to heart and kidney diseases. Aturamu (2012) reported chloride concentration values range between 4.5 mg/L and 69 mg/L which also indicate a low chloride concentration in water samples.

Alkalinity in water samples analyzed fell below WHO permissible limit (200 mg/L). The alkalinity values ranged between 16 mg/L and 92 mg/L. Alkalinity of water is its quantitative capacity to react with a strong acid to a designated pH. Excessive alkalinity in water is not good for irrigation which leads to damage of the soil and consequently leads to reduction in crop yield (Gyamfi et al., 2012). Alkalinity ranged of 2.5 mg/L to 5.5 mg/L was obtained by (Gyamfi et al., 2012).

Hardness of water (mg/L CaCO3) is an important measure of pollution. It is the measure of capacity of water to react with soap. The higher the water hardness the more soap is required to foam. The hardness concentration of the samples ranged between 34 mg/L and 226 mg/L which all fall below ANZECC and WHO permissible limit (500 mg/L). Calcium hardness and magnesium hardness in all the water samples fell below WHO permissible limit. The samples are observed to be safe for consumption for both human and livestock. These values are higher than that of Aturamu (2012) who obtained values ranged between 67 mg/L and 300 mg/L. Although Deshpande and Aher (2012) obtained a value range beyond the permissible limit which is an indication of high content of calcium and magnesium in the water samples.

High level of sulphate in water may enhance corrosion of distribution system. It gives water a bad taste. The sulphate concentration values gotten is generally low and ranged between BDL (below detection limit) and 2.1 mg/L as shown in Table1. Sulphate in the samples was found to fall below ANZECC and WHO permissible limit (200mg/L). Aturamu (2012) also obtained a value ranged between BDL and 30.1 mg/L.High concentration of nitrate in water might contribute to illness of infant called methamoglobinemia. The concentration of nitrate in the water samples ranged between 0.01 mg/L and 8 mg/L as shown in Table1. This indicates that the samples value of nitrate concentration fell below WHO permissible limit (50 mg/L). With this nitrate value range, the water can be said to be save for consumption. (Hakim et al., 2009) also observed a value range between 0.10 mg/L and 1.85 mg/L in ground water samples. Okogbue and Ukpai (2012) observed a value above the permissible limit which may be due to leachates from urban and improper disposal of farm wastes.

Biochemical oxygen demand is used as an experimental measure of the amount of biochemically degradable organic matter present in a water sample. The BOD values of the samples ranged between 0.7 mg/L and 7.5 mg/L out of which samples 10 and 13 are beyond WHO permissible limit (3mg/L) while most samples fell below the limit as shown in Table1. This was higher than results ranged between 0.6 mg/L and 2.1 mg/L obtained by Karvita and Smriti (2013). Mohamed and Zahir (2013) also obtained a high value range which might be as a result of discharge from domestic, industrial and municipal sewage. A DO value range between 10.7 and 19.0 was obtained which fell beyond WHO permissible limit of 5mg/L.

### *3.2 Trace Metals*

Sodium and potassium are minerals that occur naturally in groundwater, resulting from industrial domestic wastes and contribute to water salinity (Mohamed and Zahir, 2013). The values of sodium observed in the water samples range between 20.821 mg/L and 54.301 mg/L as shown in Table 2. The values fell within the permissible limit recommended by WHO (200 mg/L).This results compared favourably with values ranged of 20 mg/L and 96 mg/L obtained by Mohamed and Zahir (2013). Deshpande and Aher (2012) obtained a higher value range in contrary to the permissible limit which might be due to closeness of the borehole to river or stream.

Potassium and sodium are naturally occurring elements in groundwater. Potassium is an essential element in human nutrition (Gyamfi et al., 2012). The potassium values for the groundwater are obtained range between 14.860 mg/L and 48.664 mg/L. The values obtained were of acceptable limit for drinking and livestock consumption according to ANZECC and WHO permissible limit (200 mg/L). The results was lower than values between 5.3 mg/L and 184 mg/L reported by Ackah et al, (2011) although a higher value range was obtained by Deshpande and Aher (2012) which might be due to the presence of igneous rock and sedimentary rock in the area.

Table 1: Physico-chemical parameters of bore well and dug well in Ilara-Mokin Town

| Well no | Temp °C | Ph | EC µS/cm | Chloride mg/L | Turbidity NTU | Hardness mg/L | Mg HD mg/L | Ca HD mg/L | Acidity mg/L | Alkalinity mg/L | DO mg/L | BOD mg/L | $SO_4^{2-}$ mg/L | $NO_3^-$ mg/L | TDS mg/L | TSS mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 5.7 | 133 | 35.45 | 0 | 66 | 37 | 29 | 40 | 68 | 10.7 | 0.7 | 0.001 | 5.3 | 72.8 | 54.01 |
| 2 | 31 | 6.2 | 185 | 29.78 | 1.9 | 64 | 3 | 61 | 60 | 80 | 11.8 | 3 | 0.52 | 2.8 | 134.76 | 89.72 |
| 3 | 31 | 5.8 | 191 | 58.14 | 0 | 56 | 12 | 44 | 100 | 16 | 12.6 | 2.6 | BDL | 0.11 | 135.04 | 68.13 |
| 4 | 29 | 5.7 | 188 | 63.81 | 0 | 86 | 45 | 41 | 80 | 84 | 14.9 | 1.6 | BDL | 5.8 | 132.84 | 71.36 |
| 5 | 29 | 5.7 | 269 | 79.41 | 0 | 64 | 24 | 40 | 80 | 24 | 11 | 3 | 0.25 | 1.1 | 192.67 | 148.22 |
| 6 | 28 | 6 | 147 | 42.54 | 0 | 60 | 13 | 47 | 60 | 32 | 13.2 | 0.9 | BDL | 0.75 | 104.38 | 116.52 |
| 7 | 29 | 5.9 | 147 | 58.14 | 0 | 60 | 26 | 34 | 120 | 24 | 14 | 2 | 0.7 | BDL | 104.32 | 81.32 |
| 8 | 30 | 5.8 | 124 | 45.38 | 0 | 34 | 9 | 25 | 80 | 20 | 13.5 | 1.3 | 0.3 | 6 | 89.61 | 51.42 |
| 9 | 28 | 5.9 | 352 | 136.13 | 0 | 82 | 47 | 35 | 100 | 24 | 14 | 1.9 | 0.65 | 1 | 251.53 | 141.31 |
| 10 | 30 | 5.9 | 143 | 48.21 | 3.7 | 38 | 12 | 26 | 60 | 60 | 16.8 | 5.3 | BDL | 8 | 97.92 | 113.28 |
| 11 | 28 | 6.4 | 205 | 52.47 | 1.4 | 78 | 46 | 32 | 80 | 48 | 11.3 | 0.8 | 0.7 | 2.4 | 145.28 | 106.36 |
| 12 | 28 | 5.8 | 90 | 35.45 | 0.2 | 34 | 8 | 26 | 120 | 32 | 12.1 | 3 | 0.001 | 3.5 | 67.21 | 23.48 |
| 13 | 30 | 5.9 | 93 | 38.29 | 0 | 34 | 10 | 24 | 40 | 40 | 19 | 7.5 | BDL | 1.2 | 65.28 | 51.08 |
| 14 | 28 | 5.5 | 237 | 76.57 | 0.5 | 62 | 22 | 40 | 120 | 24 | 15 | 2.5 | 0.001 | 0.01 | 167.68 | 86.42 |
| 15 | 29 | 6.3 | 448 | 119.11 | 0.9 | 126 | 47 | 79 | 140 | 36 | 14.5 | 2.5 | 0.52 | 1.2 | 328.32 | 176.46 |
| 16 | 30 | 7 | 541 | 107.77 | 0 | 226 | 104 | 122 | 140 | 92 | 14.5 | 1.4 | 2.1 | 6.2 | 311.04 | 192.18 |
| mean | 29.25 | 5.97 | 218.31 | 64.17 | 0.54 | 73.13 | 29.06 | 44.06 | 88.75 | 44.00 | 13.68 | 2.50 | 0.52 | 3.02 | 150.04 | 98.20 |
| Min | 28.00 | 5.50 | 90.00 | 29.78 | 0.00 | 34.00 | 3.00 | 24.00 | 40.00 | 16.00 | 10.70 | 0.70 | 0.00 | 0.01 | 65.28 | 23.48 |
| Max | 31.00 | 7.00 | 541.00 | 136.13 | 3.70 | 226.00 | 104.0 | 122.0 | 140.00 | 92.00 | 19.00 | 7.50 | 2.10 | 8.00 | 328.32 | 192.18 |
| stdev | 1.06 | 0.36 | 127.75 | 31.91 | 1.02 | 47.07 | 25.40 | 25.31 | 32.63 | 25.00 | 2.19 | 1.76 | 0.59 | 2.60 | 82.25 | 47.62 |
| WHO Std | 28 | 6.5-8.5 | 1500 | 250 | 5 | 500 | | | | 200 | 5 | 3 | 200 | 50 | 1000 | 1000 |

BDL = Below Detection limit

Table 2: Trace Metals concentration (mg/L) in the water samples analysed

| Well nos | Na | K | Ca | Mg | Cu | Fe | Mn | Zn | Pb | Cd |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.482 | 44.333 | 63.700 | 35.130 | 0.646 | 1.008 | 0.583 | 0.048 | BDL | 0.002 |
| 2 | 28.281 | 31.000 | 40.600 | 46.930 | 0.640 | 1.245 | 0.092 | 0.013 | 0.013 | 0.031 |
| 3 | 32.424 | 31.000 | 35.400 | 60.720 | 0.720 | 2.142 | 0.354 | 0.026 | 0.009 | BDL |
| 4 | 28.667 | 34.667 | 40.200 | 27.200 | 0.603 | 1.922 | 0.322 | 0.024 | BDL | 0.024 |
| 5 | 27.126 | 26.000 | 50.650 | 54.520 | 0.672 | 1.034 | 0.511 | 0.001 | 0.014 | 0.008 |
| 6 | 21.538 | 35.000 | 28.600 | 10.140 | 0.616 | 0.320 | 0.057 | 0.008 | 0.010 | 0.062 |
| 7 | 26.000 | 34.333 | 48.200 | 69.320 | 0.640 | 1.927 | 0.293 | 0.013 | 0.021 | BDL |
| 8 | 23.634 | 31.000 | 33.640 | 16.070 | 0.690 | 2.310 | 0.084 | 0.033 | 0.009 | BDL |
| 9 | 38.641 | 48.664 | 60.200 | 48.170 | 0.603 | 2.133 | 0.373 | 0.051 | 0.013 | 0.002 |
| 10 | 31.663 | 35.000 | 36.400 | 28.330 | 0.620 | 2.370 | 0.517 | 0.042 | BDL | 0.006 |
| 11 | 20.821 | 39.373 | 60.000 | 89.110 | 0.862 | 0.721 | 0.322 | 0.043 | 0.012 | 0.002 |
| 12 | 33.938 | 14.860 | 56.260 | 31.630 | 0.714 | 1.314 | 0.051 | 0.004 | 0.014 | 0.003 |
| 13 | 27.332 | 36.000 | 52.000 | 74.200 | 0.667 | 2.393 | 0.527 | 0.031 | 0.014 | 0.003 |
| 14 | 23.143 | 29.333 | 47.500 | 29.500 | 0.583 | 2.710 | 0.333 | 0.021 | 0.012 | BDL |
| 15 | 54.301 | 47.651 | 86.200 | 58.340 | 0.746 | 2.741 | 0.672 | 0.051 | 0.023 | 0.014 |
| 16 | 27.612 | 35.000 | 60.140 | 44.830 | 0.912 | 0.672 | 0.352 | 0.015 | 0.010 | 0.006 |
| Min | 20.821 | 14.860 | 28.600 | 10.140 | 0.583 | 0.320 | 0.051 | 0.001 | 0.009 | 0.002 |
| Max | 54.301 | 48.664 | 86.200 | 89.110 | 0.912 | 2.741 | 0.672 | 0.051 | 0.023 | 0.062 |
| Mean | 29.475 | 34.576 | 49.981 | 45.259 | 0.683 | 1.685 | 0.340 | 0.027 | 0.013 | 0.014 |
| Stdev | 8.093 | 8.240 | 14.529 | 21.728 | 0.092 | 0.778 | 0.193 | 0.017 | 0.004 | 0.018 |
| WHO Std | 200 | 200 | 75 | 50-150 | 1 | 0.3 | 0.1-0.5 | 3 | 0.01 | 0.003 |

Magnesium is a common constituent in natural water and its salts contribute to water hardness which break down when heated forming scale in boiler (Mohamed and Zahir, 2013). The values obtained for magnesium concentrations in samples ranged between 10.14 and 89.11, this indicates that all samples fell within WHO permissible limit (150mg/L). Similar results ranged between 11 mg/L and 46 mg/L were obtained by Aturamu (2012).

Copper is found mainly as a sulphide, oxide, or carbonate in the minerals. Copper enters into water through mineral dissolution, industrial effluent and corrosion of water alloy distribution pipes. The copper concentration values obtained in this study ranged between 0.583 mg/L and 0.912 mg/L. The copper values for all samples are found within the permissible limit (1.0 mg/L) of WHO. This indicates that the water samples are safe for consumption as regards copper contamination.

The concentrations of iron in all the water samples were beyond the WHO permissible limit of 0.3 mg/L. Concentrations measured range between 0.32 mg/L and 2.741mg/L. Iron is an essential element in human nutrition. Amount to be consumed daily is age, sex, physiological status and bio-availability dependent. It has little effect on health hazard but it is considered as nuisance in excess.

Similar results ranged between 1.076 mg/L and 3.368 mg/L was obtained by (Gyamfi et al., 2012) which was attributed to high iron-rich ore deposit (siderite and pyrite) in the area. The concentration of manganese in the water samples ranged between 0.051 mg/L and 0.672 mg/L. Samples 2, 3, 4, 6, 7, 8, 9, 11, 12, 14, and 16 respectively are within WHO permissible limit (0.5 mg/L) while samples 1, 5, 10, 13 and 15 respectively are beyond the permissible limit. High concentrations of manganese are observed as a result of agricultural practices, fertilizers, sewage and animal waste disposal. A high concentration of manganese is toxic and usually bad in terms of taste, odor and discoloration of food (Tahlawiet al., 2014). Tahlawiet al. (2014), reporte*d* similar results ranged between 0.001 mg/L and 2.6 mg/L.

Zinc is an essential and beneficial element in body growth (Gyamfiet al., 2012). The values of zinc measured in all the samples were within WHO permissible limit (3.0 mg/L). The values obtained ranged between 0.001 mg/L and 0.051 mg/L. This result compared favourably with values ranged between 0.008 mg/L and 0.06 mg/L obtained by Ackahet al. (2011).

Lead is a poisonous to human health. The concentration of lead present in the water samples varied between BDL and 0.023 mg/L.Samples 1,3,4,6,8,10 and 16 respectively fell within the

WHO permissible limit (0.01 mg/L) while samples 2, 5, 7, 9, 11, 12, 13, 14 and 15 respectively are above the permissible limit. However, concentration of lead in samples 1, 4 and 10 were below the detection limit.

The concentration of cadmium present in the water samples was found to be between BDL and 0.062 mg/L. Samples 1, 3, 7, 8, 9, 11, 12, 13 and 14 values respectively are within the WHO permissible limit (0.003 mg/L) while samples 2, 4, 5, 6, 10, 15 and 16 values respectively are above the permissible limit. However, concentration of lead in samples 3, 7, 8 and 14 were below the detection limit.

### 3.3 *Quality Assessment as Irrigation Water*

Groundwater is a good source of irrigation water. The groundwater of Ilara-Mokintown was classified on the basis of sodium adsorption ratio (SAR), percentage sodium (Na %), magnesium hazard (MH), kelley's ratio (KI) and soluble sodium percent (SSP) respectively as shown in Table 3.

The sodium adsorption ratio indicates the effect of relative cation concentration on sodium accumulation in soil. The potential for sodium hazard increases with high sodium adsorption ratio. The SAR of content of the studied area water samples ranged between 2.411 and 6.387 with a mean value 4.384. All the water samples fell within the water class grade "excellent" hence the water samples are fit for irrigation purpose according to SAR water class grade. (Hakim *et al.,* 2009) got a similar result range between 0.27 and 0.54. Excess concentration of sodium in water produces an undesirable effect, changing soil property thereby reducing soil permeability.

The Na % of water samples in the study areas as shown in Table 4, ranged between 28.76 and 59.34 with a mean value 4.37 which indicate that 44 % of the water samples fell within the water class grade "good" and 56 % fell within the class grade permissible, hence the water samples are fit for irrigation purpose according to Na % water class grade.

Calcium and magnesium maintain a state of equilibrium in groundwater. More magnesium in water will affect the soil quality and reduce crop yield (Tahlawiet al., 2014). The calculated MH values ranged between 26.174 and 63.171 with a mean value 45.385. According to MH class grade 62.5% of the water samples are suitable for irrigation while 37.5 are unsuitable. Similar result of 62.39% suitable and 37.61% unsuitable was also reported by Tahlawiet al. (2014)

Kelley's ratio was used to evaluate water based on level of sodium measured against calcium and magnesium. It is used to estimate sodium level in water (Deshpandeet al., 2011). The calculated KI values ranged between 0.140 and 0.556 with a mean value 0.337, which indicate that all the water samples fell within the suitable grade class of KI. This implies that 100 % of the water samples are fit for irrigation purpose. Tahlawiet al. (2014) arrived at a similar result 82.09 % suitable while 17.91 % unsuitable.

The percentage soluble sodium calculated range between 12.253 and 35.718 with a mean value 24.718 which indicates that 100 % of the water samples fell below 50. This proved all the water samples to be suitable for irrigation purpose. Hakim et al. (2009) also reported a value ranged between 8.135 and 24.28 which implies 100 % suitability of the water samples as shown in Table 3 above for irrigation purpose.

Table 3: Groundwater classification for Irrigation purposes

| Classification pattern | Categories | Ranges | Number of wells | Percentage of wells |
|---|---|---|---|---|
| Percentage sodium (Na%) | Excellent | 0-20 | 0 | 0 |
| | Good | 20-40 | 7 | 44 |
| | Permissible | 40-60 | 9 | 56 |
| | Doubtful | 60-80 | 0 | 0 |
| | Unsuitable | >80 | 0 | 0 |
| Sodium absorption ratio (SAR) | Excellent | 0-10 | 16 | 100 |
| | Good | 10-18 | 0 | 0 |
| | Doubtful | 18-26 | 0 | 0 |
| | Unsuitable | >26 | 0 | 0 |
| Magnesium hazard (MH) | Suitable | <50 | 10 | 62.5 |
| | Unsuitable | >50 | 6 | 37.5 |
| Kelley's ratio (KI) | Suitable | <1 | 16 | 100 |
| | Unsuitable | >=1 | 0 | 0 |
| Soluble sodium percent (SSP) | Suitable | <=50 | 16 | 100 |
| | Unsuitable | >50 | 0 | 0 |

Table 4: Values of MH, KI, SAR, Na %, and SSP

| Well nos | MH | KI | SAR | Na% | SSP |
|---|---|---|---|---|---|
| 1 | 35.546 | 0.268 | 3.767 | 41.743 | 21.133 |
| 2 | 53.616 | 0.323 | 4.275 | 40.379 | 24.420 |
| 3 | 63.171 | 0.337 | 4.677 | 39.753 | 25.224 |
| 4 | 40.356 | 0.425 | 4.938 | 48.445 | 29.841 |
| 5 | 51.840 | 0.258 | 3.741 | 33.561 | 20.504 |
| 6 | 26.174 | 0.556 | 4.894 | 59.340 | 35.731 |
| 7 | 58.986 | 0.221 | 3.392 | 33.923 | 18.116 |
| 8 | 32.327 | 0.475 | 4.741 | 52.360 | 32.223 |
| 9 | 44.450 | 0.357 | 5.249 | 44.617 | 26.284 |
| 10 | 43.766 | 0.489 | 5.566 | 50.736 | 32.848 |
| 11 | 59.761 | 0.140 | 2.411 | 28.759 | 12.253 |
| 12 | 35.988 | 0.386 | 5.120 | 35.700 | 27.857 |
| 13 | 58.796 | 0.217 | 3.441 | 33.415 | 17.802 |
| 14 | 38.312 | 0.301 | 3.730 | 40.530 | 23.110 |
| 15 | 40.363 | 0.376 | 6.387 | 41.361 | 27.309 |
| 16 | 42.707 | 0.263 | 3.811 | 37.362 | 20.826 |
| Minimum | 26.174 | 0.140 | 2.411 | 28.759 | 12.253 |
| Maximum | 63.171 | 0.556 | 6.387 | 59.340 | 35.731 |
| Mean | 45.385 | 0.337 | 4.384 | 41.374 | 24.718 |

Table 5: Correlation matrix of groundwater physio-chemical parameters

| | | pH | EC µS/cm | Chloride mg/L | Turbidity NTU | Hardness mg/L | Mg HD mg/L | Acidity mg/L | Alkalinity mg/L | DO mg/L | BOD mg/L | SO42- mg/L | NO3- mg/L | TDS mg/L | TSS mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | Pearson Correlation | 1 | .656** | .317 | .148 | .794** | .680** | .330 | .493 | .006 | -.165 | .870** | .204 | .575* | .629* |
| | Sig. (2-tailed) | | .006 | .232 | .585 | .000 | .004 | .211 | .052 | .983 | .542 | .000 | .449 | .020 | .009 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| EC µS/cm | Pearson Correlation | .656** | 1 | .869** | -.087 | .898** | .820** | .641** | .234 | .013 | -.257 | .752** | -.022 | .980** | .884* |
| | Sig. (2-tailed) | .006 | | .000 | .750 | .000 | .000 | .008 | .382 | .962 | .337 | .001 | .935 | .000 | .000 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Chloride mg/L | Pearson Correlation | .317 | .869** | 1 | -.185 | .634** | .663** | .638** | -.095 | .127 | -.187 | .506 | -.193 | .907** | .767* |
| | Sig. (2-tailed) | .232 | .000 | | .492 | .008 | .005 | .008 | .727 | .639 | .487 | .054 | .474 | .000 | .001 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Turbidity NTU | Pearson Correlation | .148 | -.087 | -.185 | 1 | -.147 | -.206 | -.210 | .296 | .170 | .334 | .120 | .389 | -.060 | .138 |
| | Sig. (2-tailed) | .585 | .750 | .492 | | .587 | .443 | .435 | .266 | .530 | .206 | .670 | .136 | .825 | .611 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Hardness mg/L | Pearson Correlation | .794** | .898** | .634** | -.147 | 1 | .929** | .549* | .514* | -.003 | -.347 | .853** | .174 | .809** | .750* |
| | Sig. (2-tailed) | .000 | .000 | .008 | .587 | | .000 | .028 | .042 | .992 | .188 | .000 | .520 | .000 | .001 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Mg HD mg/L | Pearson Correlation | .680** | .820** | .663** | -.206 | .929** | 1 | .480 | .479 | -.002 | -.403 | .800** | .234 | .726** | .664* |
| | Sig. (2-tailed) | .004 | .000 | .005 | .443 | .000 | | .060 | .060 | .993 | .121 | .000 | .384 | .001 | .005 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Acidity mg/L | Pearson Correlation | .330 | .641** | .638** | -.210 | .549* | .480 | 1 | -.183 | -.022 | -.277 | .496 | -.219 | .656** | .412 |
| | Sig. (2-tailed) | .211 | .008 | .008 | .435 | .028 | .060 | | .497 | .936 | .300 | .060 | .414 | .006 | .112 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| Alkalinity mg/L | Pearson Correlation | .493 | .234 | -.095 | .296 | .514* | .479 | -.183 | 1 | .043 | -.068 | .430 | .652** | .123 | .183 |
| | Sig. (2-tailed) | .052 | .382 | .727 | .266 | .042 | .060 | .497 | | .875 | .803 | .110 | .006 | .651 | .499 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| DO mg/L | Pearson Correlation | .006 | .013 | .127 | .170 | -.003 | -.002 | -.022 | .043 | 1 | .696** | .024 | .092 | .008 | .027 |
| | Sig. (2-tailed) | .983 | .962 | .639 | .530 | .992 | .993 | .936 | .875 | | .003 | .931 | .734 | .978 | .921 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| BOD mg/L | Pearson Correlation | -.165 | -.257 | -.187 | .334 | -.347 | -.403 | -.277 | -.068 | .696** | 1 | -.246 | -.037 | -.233 | -.173 |
| | Sig. (2-tailed) | .542 | .337 | .487 | .206 | .188 | .121 | .300 | .803 | .003 | | .377 | .892 | .385 | .522 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| SO42- mg/L | Pearson Correlation | .870** | .752** | .506 | .120 | .853** | .800** | .496 | .430 | .024 | -.246 | 1 | .290 | .654** | .681* |
| | Sig. (2-tailed) | .000 | .001 | .054 | .670 | .000 | .000 | .060 | .110 | .931 | .377 | | .294 | .008 | .005 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| NO3- mg/L | Pearson Correlation | .204 | -.022 | -.193 | .389 | .174 | .234 | -.219 | .652** | .092 | -.037 | .290 | 1 | -.127 | -.047 |
| | Sig. (2-tailed) | .449 | .935 | .474 | .136 | .520 | .384 | .414 | .006 | .734 | .892 | .294 | | .640 | .864 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| TDS mg/L | Pearson Correlation | .575* | .980** | .907** | -.060 | .809** | .726** | .656** | .123 | .008 | -.233 | .654** | -.127 | 1 | .884* |
| | Sig. (2-tailed) | .020 | .000 | .000 | .825 | .000 | .001 | .006 | .651 | .978 | .385 | .008 | .640 | | .000 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| TSS mg/L | Pearson Correlation | .629** | .884** | .767** | .138 | .750** | .664** | .412 | .183 | .027 | -.173 | .681** | -.047 | .884** | 1 |
| | Sig. (2-tailed) | .009 | .000 | .001 | .611 | .001 | .005 | .112 | .499 | .921 | .522 | .005 | .864 | .000 | |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlation matrix of groundwater heavy metals parameters

| | | Na | K | Ca | Mg | Cu | Fe | Mn | Zn | Cd |
|---|---|---|---|---|---|---|---|---|---|---|
| Na | Pearson Correlation | 1 | .357 | .625** | .131 | .047 | .465 | .450 | .409 | -.108 |
| | Sig. (2-tailed) | | .174 | .010 | .629 | .863 | .069 | .081 | .116 | .691 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| K | Pearson Correlation | .357 | 1 | .456 | .242 | .019 | .149 | .559* | .804** | .019 |
| | Sig. (2-tailed) | .174 | | .076 | .366 | .943 | .581 | .024 | .000 | .943 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Ca | Pearson Correlation | .625** | .456 | 1 | .458 | .417 | .083 | .583* | .437 | -.352 |
| | Sig. (2-tailed) | .010 | .076 | | .075 | .108 | .760 | .018 | .091 | .181 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Mg | Pearson Correlation | .131 | .242 | .458 | 1 | .447 | .037 | .407 | .196 | -.425 |
| | Sig. (2-tailed) | .629 | .366 | .075 | | .083 | .891 | .117 | .467 | .101 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Cu | Pearson Correlation | .047 | .019 | .417 | .447 | 1 | -.379 | .061 | .035 | -.241 |
| | Sig. (2-tailed) | .863 | .943 | .108 | .083 | | .148 | .822 | .897 | .368 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Fe | Pearson Correlation | .465 | .149 | .083 | .037 | -.379 | 1 | .344 | .418 | -.449 |
| | Sig. (2-tailed) | .069 | .581 | .760 | .891 | .148 | | .193 | .107 | .081 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Mn | Pearson Correlation | .450 | .559* | .583* | .407 | .061 | .344 | 1 | .554* | -.384 |
| | Sig. (2-tailed) | .081 | .024 | .018 | .117 | .822 | .193 | | .026 | .142 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Zn | Pearson Correlation | .409 | .804** | .437 | .196 | .035 | .418 | .554* | 1 | -.333 |
| | Sig. (2-tailed) | .116 | .000 | .091 | .467 | .897 | .107 | .026 | | .207 |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Cd | Pearson Correlation | -.108 | .019 | -.352 | -.425 | -.241 | -.449 | -.384 | -.333 | 1 |
| | Sig. (2-tailed) | .691 | .943 | .181 | .101 | .368 | .081 | .142 | .207 | |
| | N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

### 3.4 *Correlation of Physico-chemical Parameters of the Water Sample*

The data obtained for physico-chemical parameters of 16 water samples from Ilara-Mokin was subjected to Pearson moment correlation analysis to test the significant relationship between the water quality characteristics such as; pH, EC, Chloride, Turbidity, Hardness, Magnesium hardness, Acidity, Alkalinity, DO,BOD, Sulphate, Nitrate, TDS, TSS, Magnesium, Calcium, Potassium, Manganese, Sodium, Zinc and Copper as shown in Table 5 and Table 6. The Pearson correlation between the variables indicates the following in the water samples.

It shows that there was a strong correlation between the pH and electrical conductivity, total hardness, magnesium hardness, sulphaterespectively. This indicates that increase in pH will lead to changes in values aforementioned parameters and also implies that those parameters are pH dependent, although a weak correlation was recorded with TDS. Alkalinity of water was found to have a strong correlation with sulphate which implies that an increase in alkalinity will increase sulphate value. DO of water was found to have a strong correlation with BOD. Sulphate of the samples was found to have a strong correlation with TDS and TSS. Increase in sulphate will lead to an increase in TDS and TSS respectively. Calcium of water sample was found to have a positive strong correlation with sodium which implies an increase in calcium concentration will result to increase in sodium concentration. Zinc of water was found to have a strong correlation with potassium which implies increase in zinc will lead to an increase in potassium. A weak correlation was observed between manganese with potassium, calcium, and zinc respectively.

## 4. Conclusion

The quality characteristics of 16 groundwater samples within Ilara-Mokintown were investigated using standard methods. The study was aimed at classifying the water sample for possible utilization for drinking, domestic and agricultural uses. The results of the water samples indicated that some physico-chemical parameters such as temp (68.8 %), pH (93.8 %), DO (100.0 %), BOD (13.0 %), Ca (93.8 %), Fe (100.0 %), Mn (31.3 %), Pb (13.0 %) and Cd (43.8 %) of the water samples fell beyond water standard permissible limits which might have resulted from improper design and construction of wells, shallowness, and proximity to toilet, refuse dump sites, and agricultural farm sites. 100.0 % of other parameters such as Ec, Cl, Turb, TH, Al, So42-, No3-, TDS, TSS, Na, K, Mg, Cu and Zn fell within the permissible limits. For irrigation use 100.0 % of the water samples for SAR, KI, Na % and SSP were suitable while 62.5 % were unsuitable according to MH classification.

The Pearson correlation indicated a strong correlation between pH with electrical conductivity, total hardness, magnesium hardness, sulphate and TSS respectively. Strong correlations were also observed between Electrical conductivity with chloride and TDS, Alkalinity and sulphate, DO and BOD, Sulphate with TDS and TSS, Calcium with sodium, Zinc and potassium respectively, while a weak correlation between pH and TDS, manganese with potassium, calcium, and zinc. This implies that slight changes in the correlated parameters will have significant effect on affected parameters

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